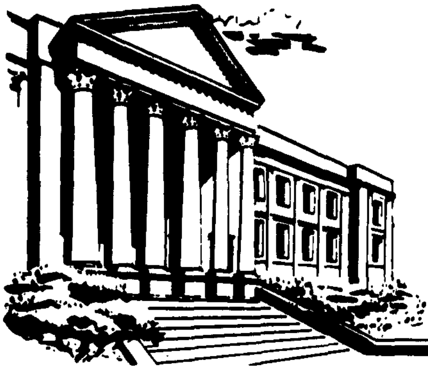

Monthly Progress Report

P-B1980-9

HERO SUPPORTING STUDIES

by

Norman P. Faunce
Paul F. Mohrbach

March 1963

Prepared for

U. S. NAVAL WEAPONS LABORATORY
Dahlgren, Virginia

Contract No. N178-8102

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ABSTRACT

Checks are under way to determine the cause of an abnormally high functioning level of RF protected MARK 7 MOD 0 ignition elements at 1 Gc.

In preparation for tests of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element at 3 and 10 Gc, special mounting hardware is in development. The new mount is for waveguide adaption, but conforms in general style to the mount used for lower frequency tests.

Additional evaluations of a tantalum feed-through capacitor have been made. Tests have been performed to determine the loss contributed by a system comprising the capacitor surrounded by a medium of salt water in varying concentrations. Results are not too conclusive, but they suggest that the loss for this system will increase with increasing conductivity of the surrounding medium.

Development of a one-ohm self-indicating load and a three-voltmeter power measuring arrangement are discussed. The latter incorporates an UHF vacuum thermocouple for an ungrounded voltmeter.

SUMMARY

The HERO test schedule outlined for the protected MARK 7 MOD 0 ignition element included evaluations at 3 Gc. Because of the relative insensitivity of the component these tests could not be performed. Consequently, a shift to 1 Gc was agreed upon.

Attempts were made to conduct 1-Gc tests during this period. Preliminary trials to find the range of functioning powers upon which to base a Bruceton schedule suggested that the 50% firing level would be exceedingly high. The level appeared to be up by at least 3 db compared to predictions based upon loss measurements, and from a previous test of the identical lot at 900 Mc.

A number of experiments were conducted to check out the evaluation system. Additional experiments are in process to determine if the item's sensitivity has been changed. Although the evidence so far does not reveal any clue to the cause for this deviation, we believe that it will be resolved during the next period. In next month's report we will present the results collected this period, together with final test data to be obtained during the early part of next month.

Tests of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element are next in line after we conclude the program on the MARK 7. Anticipating performance of the tests during this period, we had a suitable mount designed. Because these elements are to be tested at 3 and 10 Gc we will be working in waveguide systems. Suitable parts have been designed to adapt our basic waveguide mounts to accommodate these elements. These parts allow the items to be mounted in a manner similar to that used with the coaxial system.at lower frequencies.

Evaluation of the tantalum capacitors has continued. Measurements of worst-case loss was made on systems comprising the capacitor surrounded by salt water solutions; three concentrations were employed. The data suggests that the system loss is related to the surrounding medium's conductivity; the limited data available, however, do not appear to indicate an optimum conductivity. Uncertainty of the measurements, brought about by the low impedance of the system, precludes any firm conclusions. Effort to improve accuracy should precede any further analysis of this system.

To facilitate measurements of terminated power loss (TPL) a one-ohm self-indicating load, and a vacuum thermocouple voltmeter have been developed. The one-ohm load was made to fill a void in our measuring systems. Development of the thermocouple voltmeter was prompted by an interest to expedite low frequency terminated power loss measurements.

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1. RF TESTS OF MARK 7 MOD 0 IGNITION ELEMENT

Contained in the last report was a summary discussion of all test data collected to substantiate the RF protection afforded in the protected MARK 7 MOD 0 ignition element. Missing from the summary were data to be obtained from tests at 3 Gc; these tests were not performed because the required power was greater than our testing system could produce. It was decided instead to attempt tests at 1 Gc.

Though a functioning test had already been performed at 900 Mc it was decided to perform a test at 1 Gc, which was then regarded as a repeat test. The previous test, under our old procedure, did not include adjustment for systems losses. By repeating a test at a frequency not too distant we assumed that we would have a reasonable basis for a comparison between old and new data.

Because we chose to test at a slightly higher frequency we anticipated a slight increase in the 50% functioning level as well as in the Bruceton levels required to perform the test. The increase, however, turned out to be far beyond our expectations. A series of experimental checks were begun to determine the cause for this apparent anomaly. By the close of the reporting period the problem had not been solved. Anticipating the emergence of a reasonable explanation from additional experiments, we will postpone discussion of this work done in this period. Results to be presented in April's report should conclude the initial outline of tests for this element.

2. RF TESTS OF MARK 1 MOD 0 SQUIB AND MARK 2 MOD 0 IGNITION ELEMENT

RF tests of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element were performed on a previous contract. This work, detailed in final summary report (F-B1805), represents an attempt to determine with reasonable precision the RF functioning sensitivity of EED's. As a consequence, a procedure was developed for precision testing within the 1 Mc to 1 Gc frequency spectrum, and tests of both the squib and ignition element were performed.

Techniques developed on the present program permit the precision evaluation of the MARK 1 MOD 0 squib and MARK 2 MOD 0 ignition element to be extended to 10 Gc. Tests at 3 and 10 Gc have been planned to attain this objective.

The lower frequency tests were made in especially developed coaxial firing mounts, having an unusual collet device with contacting fingers. The new tests planned at 3 and 10 Gc will be made in waveguide systems, for which the coaxial mounts are not adaptable. Accordingly, new mounts were designed.

For both 3 and 10 Gc we have on hand one basic waveguide mount which is made to accommodate various types of devices. This is achieved by means of adapter plates and interchangeable probes which are individually constructed for each type of device. For the sake of expediency, the adapter hardware is usually made as simple as possible for routine tests. However, a mounting assembly consistent with that designed for the lower frequencies was considered necessary for the precision firing tests of the squib and ignition element.

In Figure 2-1, a cross section of the 3 Gc waveguide mount developed this period for firing the MARK 2 MOD 0 ignition element is shown. The basic waveguide mount includes the waveguide section and

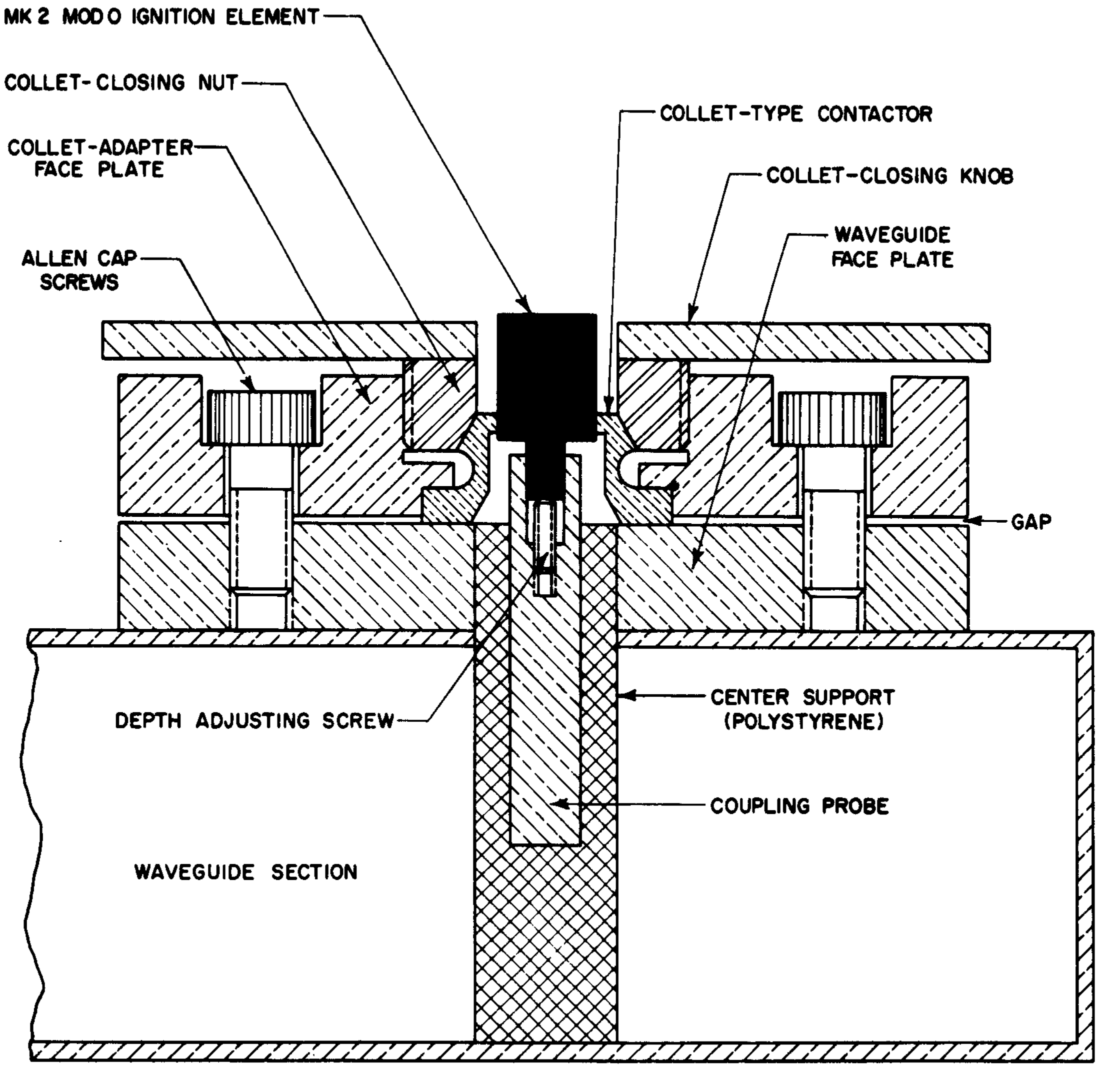

FIG. 2-1. CROSS SECTION OF FIRING MOUNT

the attached face plate. The added parts were especially designed for mounting the ignition element as it had been for low frequency tests. The following brief discussion will explain some of the features of this new mount.

RF power is taken from the waveguide by means of a coupling probe. The probe extends to the center of the waveguide and is rigidly held by a polystyrene support. Contacting fingers at the upper end engage the center conductor of the ignition element. An adjustment screw, in the center of the probe, is set to fix the depth of insertion of the elements.

A clearance gap of .002 inch between the two face plates insures positive contact and an RF seal will be made at the base of the collet contactor. When the knob is turned, the collet-closing nut bears against the collet; this forces the contacting fingers to engage the base of the ignition element, providing both the electrical and mechanical attachment necessary.

The adapter parts shown in the figure will also fit the basic 10 Gc firing mount. A shorter probe and polystyrene support are required because the 10 Gc waveguide is smaller in cross section. Many of these parts are also used to mount the MARK 1 MOD 0 squib. However, the collet and center conductor for this device differ in design, to accommodate the twin leads.

This new mount has not been tested, but appears to be superior - mechanically, at least - to previous ones. Tests planned at 10 Gc for the squib and ignition element will prove its worth.

3. TESTS OF TANTALUM CAPACITORS

Data collected in the past several weeks indicate that a particular type of tantalum capacitor might possibly provide a reasonable level of dissipative loss at lower frequencies. Though it may be shown that these items will fail in respect to power handling capability, our interest has been in exploring their lossy character in some detail.

Because these feed through capacitors bear, in part, a resemblance to a proposed model for an optimum lossy medium, the Naval Weapons Laboratory has encouraged us to extend our study of them. It has been recommended that we explore the systems comprising the feed through capacitor surrounded by various concentrations of salt water.

Results have been obtained from measurements of three units, each surrounded by salt water solutions in three concentrations. These concentrations of salt water were made by combining respectively 100, 250 and 400 grams of sodium chloride in one liter of water, resulting in solutions with conductivities of 0.0268, 0.0666 and 0.0725 mhos per centimeter.

The loss was found from measurements of the system's input impedance with different terminating impedances, our standard procedure for low frequency evaluation of worst case (matched) attenuation. Table 3-1 contains the resulting data, which is shown in contrast to the loss attributed to the capacitor by itself. Entries missing from the table are due to "blow-ups" in the computer program used to process the measured values, to give the worst case loss. When these data are important they can be extracted by introducing minimal changes in the input data.

Table 3-1

LOSS MEASUREMENTS ON SALT WATER-TANTALUM CAPACITOR SYSTEMS

	Frequency (Mc)	db loss for capacitor alone	in 100 g/l salt sol'n	in 250 g/l salt sol'n	in 400 g/l salt sol'n
Capacitor No. 1	.520	6.90	2.18	3.45	3.52
	1.0	-	1.50	-	4.99
	5.0	-	4.34	15.75	9.01
	10.0	6.06	4.33	6.72	6.73
Capacitor No. 2	.520	9.11	3.42	-	-
	1.0	2.75	2.87	-	2.86
	5.0	8.53	3.88	9.19	4.05
	10.0	12.75	4.05	2.04	6.89
Capacitor No. 3	.520	8.22	0.73	3.73	-
	1.0	2.45	2.81	0.45	2.28
	5.0	14.43	4.55	6.79	4.07
	10.0	0.87	3.55	7.63	5.86

• Because of the characteristic low impedance of the systems being evaluated, little confidence is given to these data. Very slight errors in measurements can account for wide variations in determined loss. The uncertainty of the results induced us to make a few check measurements. These results indicated that the data are at best accurate to within 10% of the tabulated value, but may in many cases deviate by 20 to 30%.

In view of these uncertainties, there is little to be learned from the results. Indications are that the system comprising salt water medium and a capacitor becomes more lossy as the concentrations of the solutions increase. The data do not support the conjecture that an optimum loss will be obtained for a specific conductivity of surrounding medium, other than to indicate that optimum loss occurs when the surrounding medium is the normally "good" coaxial outer conductor. Additional experiments with solutions of higher conductivity would be in order if the measurement could be made more accurately. Attention will be given to improving the evaluation of this sort of component, and when improved techniques become available we will return to this investigation.

4. INSTRUMENTATION

Work was done this month to improve our technique for measuring terminated power loss. Because of the emphasis upon fixes under development to operate into one ohm loads, we prepared a UHF thermocouple as a self-indicating one ohm termination. Additionally, we have looked into a three voltmeter technique for measuring power. This new self-indicating load and power measuring procedure is intended to expedite measurement of terminated power loss (TPL) in the 1 kc to 1 Mc frequency range.

4.1 An UHF Vacuum Thermocouple as a Self-Indicating Load

Several UHF Vacuum thermocouples, were obtained and assembled into a simple mount. A General Radio coaxial RF connector was provided at the input and a BNC connector for the dc output. Figure 4-1 is a view of one of these assembled thermocouples with the cover removed. The few parts required can be clearly seen in the picture. The heavy brass case serves as a common ground for both the RF and the dc circuit. The case is also an efficient shield against ambient RF and temperature effects. A small RF by-pass condenser is connected directly across the thermocouple dc output leads.

The particular thermocouple shown has a heater resistance of 1 ohm which produces a nominal output of 7 milliwatts for an input of 22.5 milliwatts (150 ma dc). It is possible to calibrate the output to indicate the current, voltage, or power associated with the heater element. A calibration made with dc input is assumed valid for RF inputs up to 35 Mc, the maximum frequency for which the elements are designed.

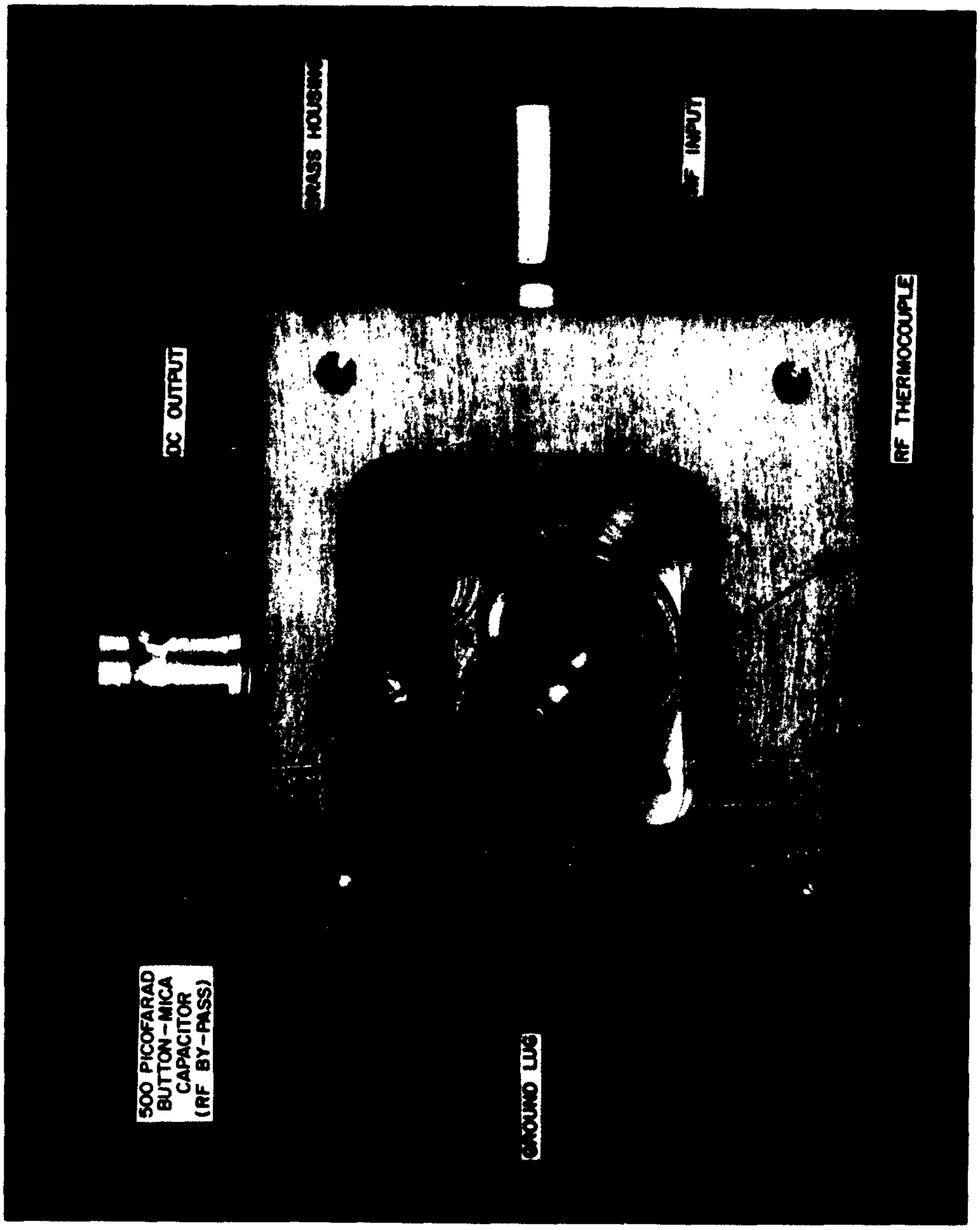

FIG. 4-1. RF THERMOCOUPLE ASSEMBLY (1 OHM LOAD)

In Figure 4-2, the 1-ohm thermocouple is shown connected to a sensitive (0-3 mv) dc millivoltmeter. Such an indicator is preferable to an electronic millivoltmeter when only moderate sensitivity is required, since the possibility of ground loops and direct RF pickup is eliminated. Figure 4-3 is a calibration curve for the thermocouple when connected to this particular meter. Reference to the curve shows that 1 milliwatt of power to the heater gives a readable deflection of 0.28 millivolts. If greater resolution is required, a more sensitive (electronic) meter must be used.

4.2 Three-Voltmeter Method for Measuring Power to an Arbitrary Load

The power into a load having both real and reactive components determined by the basic three-voltmeter method is given by,

$$P_{in} = \frac{V_1^{\ 2} - V_R^{\ 2} - V_Z^{\ 2}}{2R_1}$$

Where the symbols refer to quantities indicated in Figure 4-4.

The circuit given in Figure 4-4 requires that the voltmeter used to measure V_R must be isolated from ground which increases the chances of picking up unwanted signals in the circuit. If we substitute a vacuum thermocouple for all or part of R_1 in the three voltmeter circuit, V_R can be determined with minimum interference since we have maximum isolation of the voltmeter with such a system. Because a dissipative element is placed in series with the load in such a circuit, it is necessary to have relatively large power outputs from the generator if adequate precession is to be obtained. However, the technique has the advantage of eliminating the need for phase measurements and minimizes the pickup problems created by having the voltmeter above ground.

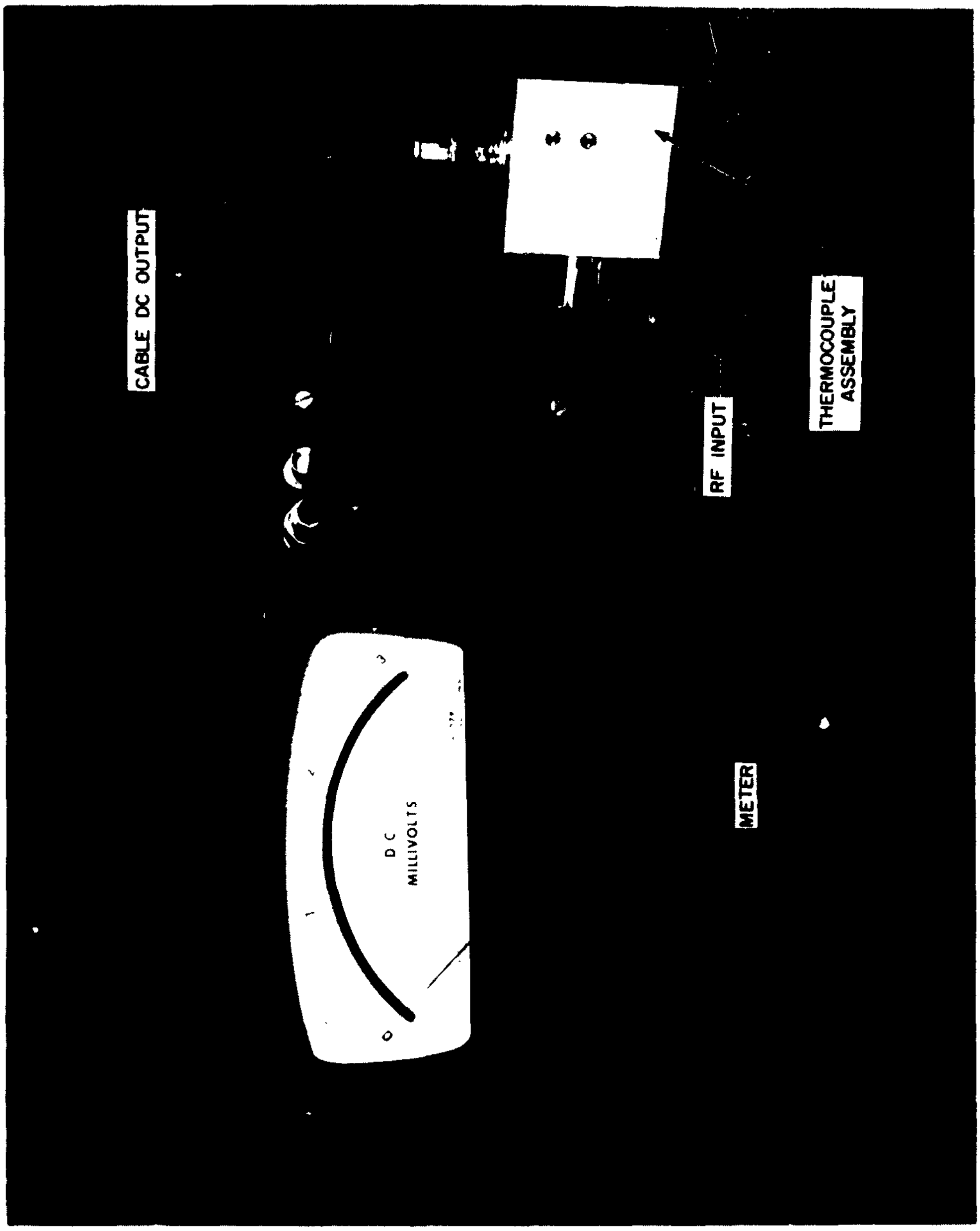

FIG. 4-2. THERMOCOUPLE ASSEMBLY AND DC OUTPUT METER

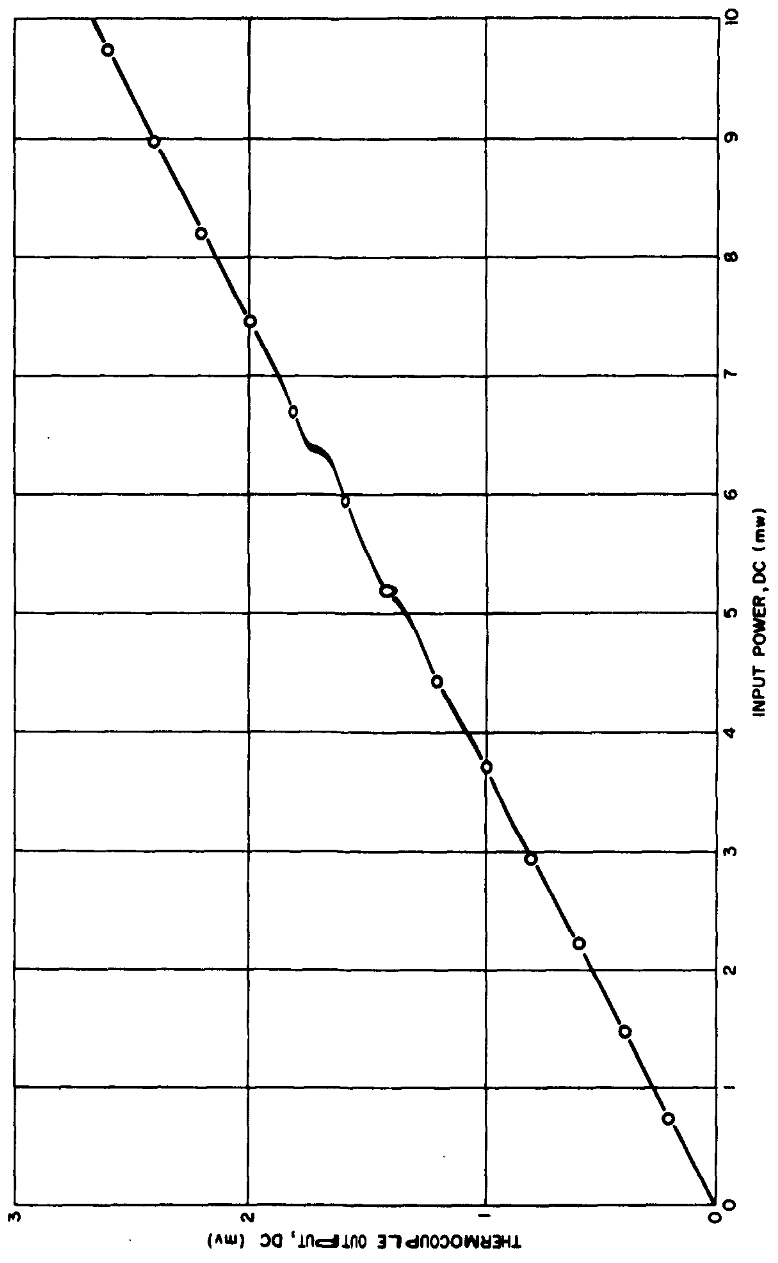

FIG. 4-3. ONE OHM LOAD CALIBRATION

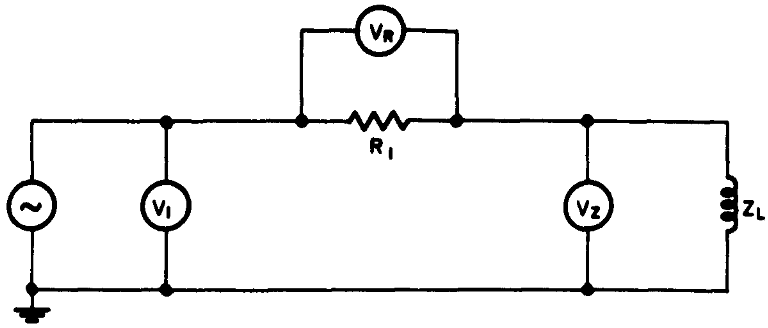

FIG. 4-4. THREE VOLTMETER POWER MEASURING CIRCUIT ARRANGEMENT

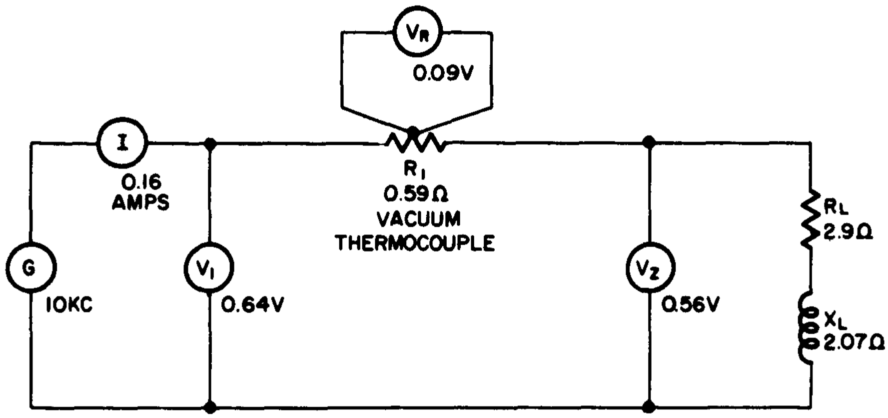

FIG. 4-5. 10KC TEST ARRANGEMENT

To verify operation of our newly developed equipment, we set up the circuit shown in Figure 4-5. A low loss RF choke coil was chosen as an arbitrary load, and we set out to measure the power it would dissipate when fed by a 10 kc signal source. The impedance of the load was first determined and the thermocouple voltmeter was calibrated to indicate the series current flow as well. Data shown in Figure 4-5 were then obtained. We may compute power from these data in a number of ways, including the expression for three voltmeter data as well as the technique which uses phase shift. By all means of calculation we obtain a value between .073 and .074 watts.

The agreement of the values of net power obtained by these different calculations is considered reasonable proof that the three-voltmeter system employing the vacuum thermocouple as a voltmeter will give accurate results in a practical test.

ACKNOWLEDGEMENTS

Acknowledgement is made of the contribution of John P. Warren to the work and its presentation in Sections 2 and 4.

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